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Performance Evaluation of Marine Zoning in the Florida Keys National Marine Sanctuary

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Abstract
This multi-year project has used a multi-tiered approach to evaluate Marine Protected Areas in the Florida Keys National Marine Sanctuary. During the Federal Fiscal Year 10 (Oct. 11- Sept. 12), spatial and temporal rates of movement of acoustically tagged snappers and groupers were measured in the Tortugas region, including annual spawning migratory movements between Riley's Hump the Tortugas Ecological Reserves, and the Dry Tortugas National Park, including the Research Natural Area. Results will be used to assess the importance of habitat linkages between adjacent marine protected areas and provide information for an ecosystem-based approach to management of marine resources.

Background
This multi-year project uses a multi-tiered approach to evaluate Marine Protected Areas (MPAs) in the Florida Keys National Marine Sanctuary (FKNMS). The FKNMS MPAs were established to resolve user conflicts, to protect critical coral reef ecosystems from exploitation, and to insure the sustainability of valuable marine resources. In past years, our research focused on the efficacy of one of the largest ecological reserves in the FKNMS, the Western Sambo Ecological Reserve (WSER). We continue to evaluate the efficacy of this reserve design relative to habitat use, population structure and animal movement, recognizing the potential need to alter MPA boundaries to include additional habitat for spawning of species such as lobsters, snappers and groupers. The present project builds on past research and monitoring in the FKNMS by the Florida Fish and Wildlife Conservation Commission and focuses on connectivity between the network of marine reserves in the Dry Tortugas region, including the connections between populations of fish in the Dry Tortugas National Park (DRTO), the DRTO Research Natural Area (RNA, a type of marine reserve), the Tortugas North Ecological Reserve (TNER) and spawning habitat at Riley's Hump (RH), located within the Tortugas South Ecological Reserve (TSER). The following submission summarizes annual progress on the *Performance Evaluation of Marine Zoning in the Florida Keys National Marine Sanctuary* project for October 2011 to October 2012 in three parts: 1) Dry Tortugas Finfish project; 2) Western Sambo Ecological Reserve – lobster project and 3) Florida Keys Lobster project.

DRY TORTUGAS FINFISH PROJECT

Summary report

During 2008-12, we tagged 128 fishes including: 28 mutton snapper and 10 black grouper at Riley's Hump (RH) and 28 mutton snapper and 21 black grouper within DRTO. Currently, we are maintaining 64 acoustic receivers. We found large mutton snapper spawning aggregations in 2009-10-12 and observed spawning 1–5 days after full moon in June 2009. We observed individual mutton snappers making up to 3 repetitive spawning round trips between May and August. Individuals stayed on the spawning grounds up to 10 days around full moon before returning to DRTO/RNA. In addition, in 2011 and 2012 we observed large aggragations of cubera snappers around 200 ft off the South-West edge of Riley's Hump. These results have been provided to FKNMS managers for management review.

Introduction

The TSER, TNER and RNA create a network of no-take reserves that protect 600 km^2 of coral reef habitat, adjacent to and within the DRTO, 70 miles west of Key West, FL (Figure 1). The Dry Tortugas coral reef ecosystem is unique in terms of the variety and complexity of available habitat, the diversity of biological resources, and the presence of key spawning locations that hypothetically supply larval/juvenile recruits to the Florida Keys and south Florida (Domeier, 2004; Burton et al., 2005; Ault et al., 2006). The TSER and TNER were established in the Tortugas region in 2001 and the no-take RNA was established within the DRTO in 2007. The established marine reserves and adjacent open fished areas of the Tortugas region provide an excellent system for empirical studies on habitat utilization, spillover, broad scale movements, residence times on aggregation sites, and the efficacy of a network of MPAs in protecting marine resources and conserving marine biodiversity.

This network is designed to enhance biodiversity and sustainability throughout the Tortugas and the Florida Keys coral reef ecosystem by creating refuge for various life history stages of numerous exploited fishery resources, including snappers and groupers. The purpose of our CRCP telemetry project was to determine regional connectivity and test the hypothesis that fish move from foraging grounds (RNA, TNER, and DRTO) to spawning sites in the TSER. Data will be used to assess the size, shape and site selection of the Tortugas marine reserves and their efficacy as an ecosystem-based management tool. For example, changes in reserve boundaries may be implemented to enhance or reduce spillover of key species, based on observed home ranges and movement patterns of snappers and groupers during the spawning season.

In addition, we began the effort to determine residence times and behavior of snappers and groupers in spawning aggregation areas. Snappers and groupers migrate long distances to specific sites to form spawning aggregations of 100 – 1000s of individuals at specific times of the year. Unfortunately, traditional fishery management strategies have not always accounted for the vulnerable nature of spawning events and these prime fishery targets are rapidly overfished. Recent changes in fishery regulations have placed greater emphasis on marine protected areas to preserve reef habitat, enhance reef fish production, conserve functional ecosystem processes, and protect a certain proportion of the population. After years of overexploitation, the TSER was established to protect the most important known multi-species aggregation site in the southeastern United States (Lindeman et al., 2000). Re-formation of the mutton snapper spawning aggregation has been documented since closure of the TSER to fishing, but little is known about adult reef fish movements in the region or the characterization of transient reef fish spawning aggregations at Riley's Hump.

Eventhough, recent diver surveys have successfully identified spawning aggregations in Riley's Hump and demonstrated the spatial connectivity among these reserves. Still, an important knowledge gap exists concerning the connectivity of snappers, groupers and reef fishes between deep and shallow water habitats in Riley's Hump. In 2012 as a continuation of the 2011 study of the Riley's Hump ecosystem. Scientists from the Florida Fish and Wildlife Conservation Commission (FWC) and NOAA conducted surveys of potential spawning aggregations located within the Tortugas South Ecological Reserve (TSER). The mission was to examine the connectivity between shallow and deeper habitats in RH. The project conducted visual censuses using open-circuit scuba (i.e., air, Nitrox systems), a remote operating vehicle (ROV) and acoustic sonar (split-beam echosounder) surveys. These activities were used to enhance our knowledge in the use and the distribution of snappers and groupers in deep water reefs of Riley's Hump. A detail synopsis of this cruise is provided in Appendix 1.

Materials and Methods

Finfish – Acoustic Array

The acoustic receiver array was first deployed in three phases between May and July 2008. The array covers approximately 800 km^2 and is designed to capture small scale movement and long range migrations of fishes in water 5 – 50 meters deep. In the first phase, 33 VR2 receivers were placed within the DRTO, including within and outside the borders of the RNA. This work was funded by our USGS research grant: *Efficacy of a newly-established RNA for protecting coral reef fishes within DRTO*, but is complementary to the objectives of our CRCP grant. The second phase was completed in June 2008, with an additional 23 acoustic receivers placed throughout DRTO, the TNER and open use areas of the FKNMS. The final nine receivers were set up during July 2008 at RH in the TSER. The coverage of our array is complemented by two collaborative acoustic projects: Mote Marine Laboratory's Nurse shark project (PI: Wes Pratt) and a USGS sea turtle study (PI: Kristen Hart).

The receivers were secured to a PVC stand attached to a concrete platform that functioned as ballast and provided stability. The VR2 receivers were positioned "tip up" approximately 1 meter above the seafloor inside a PVC pipe sleeve (63.5 or 76.2 mm) and secured by a tie wrap. Each receiver tip was protected by a coat of antifouling paint. A 3 m subsurface buoy was attached to a stainless steel I-bolt at the base of each receiver stand with a 6.35 mm polypropylene line. Prior to deployment, each VR2 sonic receiver was initialized in the laboratory with a personal computer and VUE software provided by the manufacturer (VEMCO; AMIRIX Systems Inc.).

Receiver sites were preselected based on reef fish population structure, habitat type, rugosity, depth, and reserve boundary locations. The VR2 receiver stand and a surface marker were dropped together from the research vessel when it was determined by a fathometer reading that the vessel was over sand substrate and site coordinates were immediately recorded upon deployment. A team of divers immediately confirmed the position and placement of the receiver stand on the seafloor. Receivers were serviced for maintenance twice per year in the field. Individual receivers were brought to the surface and data was uploaded to a personal computer using VUE software with an upload cable or by Bluetooth® technology. If the receiver required a battery replacement, the battery was replaced and the receiver was reinitialized. In addition, the subsurface buoy and line were scraped clean of fouling organisms.

Finfish – Acoustic Tagging

All fish captured at RH were surgically implanted with VEMCO V16-4H coded transmitter tags *in-situ* at 33 – 40 m. This avoided exposure of fish to barotrauma induced mortality associated with the capture of fish from relatively deep water. Fish were caught in fish traps baited with threadfin herring and sardines soaked 3 – 12 hrs. Traps were set on the south slope of RH in an area identified by Burton et al. (2005) as the focal point of the aggregation zone. Rather than hauling traps to the surface, fish were transferred from a trap to a catch bag by divers at depth. Each fish was positioned ventral side up in a V-cradle surgery station and a 2.5 cm incision was made along the midline, posterior to the pelvic girdle. Scales were removed on either side of the incision to expose the skin. The tag was implanted within the peritoneal cavity and the incision was closed with three hand tied sutures. Sterile synthetic absorbable braided sutures (VICRYL Plus; Ethicon, Inc.) with an antibacterial coating and a size 0 cutting needle were used. The entire underwater surgical procedure took approximately 3 – 6 minutes. Standard, fork and total lengths were recorded and the fish were immediately released.

Progress and Results

Finfish

During FY 2011, VR2 receivers were successfully downloaded, redeployed and are operational on or near their originally proposed locations (Figure 1). All receivers were serviced during March 2012, July/August 2012**.** Sixty-four VR2 stations have recorded more than **1.9 million** detections since May 2008 (Table 1). Stations 20, 35, 35A, and 37B have large numbers of detections (> 50,000) because of one or two fish in residence near these inshore sites. The numerous detections at stations 2 and 48 are from multiple individual fish because of the proximity of these stations to spawning habitat along the southern slope of RH All VR2s in the array are currently in deeper water (>15 m) to avoid storm surge in the future. A total of 120 fish were tagged From May 2008 and July 2012 with approximately, 2.2 million detections recorded by the FWC array during that time. Time-at-liberty for FWC tagged snappers and groupers determined by the array ranged from 114-1115 d with mean (± SE) of 754±35 d for mutton snapper (n=51), 411±7 d for yellowtail snapper (n=18), 452±47 d for black grouper (n=27), 482±237 d for red grouper (n=4), 666±292 d for Nassau grouper, *Epinephelus striatus* (n=3), and 415±0 d for goliath grouper, *Epinephelus itajara* (n=2).

During January 7th through 10th 2012, using fish traps and hook & line gear, we acoustically tagged 3 black grouper (ave. 75.7 cm), 2 gag (75.5 cm), and 1 goliath grouper 120cm. We also deployed 9 new acoustic receivers primarily along the eastern edge of Tortugas Bank and northwestern border of the RNA. In September (9/10-9/13 2012), using fish traps and hook & line gear, we acoustically tagged 3 black grouper (71.7 cm), and one 60 cm mutton snapper (Table 2). Approximately 40 % of fish tagged within the TSER have been successfully tracked greater than 20 days since the inception of the study. In 2012, results of our research was presented at the Florida Fish and Wildlife Conservation Commission (FWC) meeting, Palm Beach Gardens, Florida (June 2012).

Mutton Snapper

Mutton snapper (45.7-89.7 cm) were acoustically tagged offshore at the RH FSA (n=28) and inshore within the RNA and DRTO (n=27). A total of 1.4 million mutton snapper tag detections were recorded by the array between May 2008 and September 2012. Sixty-eight detections were recorded on the Tortugas Bank and the remaining detections were recorded at Riley's Hump (33,460) and on or near the Dry Tortugas. Individual mutton snapper (n=51) were tracked an average (mean±sd) of 315±338 days (d) with a range of 3 -1056 d.

Exploited-phase mutton snapper crossed reserve boundaries several times annually, especially during the spring/summer spawning season. Results indicate a migratory pathway exists for the seasonal movements of mutton snapper between the DRTO/RNA and the TSER, providing connectivity between marine protected areas and spawning activities (Figure 2). Currently, fifteen individual mutton snapper have been tracked making repeated migratory round trips (≤4 trips/fish/season) up to 62 km to RH. Kernel density estimates (Hawth's Analysis Tools for ArcGIS) of home range indicated 12 of these mutton snapper were residential fish of the RNA or migrated through the RNA. Daily transmitter detection frequency peaked at RH on the full moon during the spawning season (May to August) (Figure 3). Mean residence time on the spawning grounds was 7±3 d. The mean day of arrival relative to the full moon (+1±3 d) varied significantly (p=0.002), however the mean day of departure (+7±1 d; p=0.06) did not vary significantly over seven distinct spawning periods (Figure 3).

Black grouper

Grouper movements were small and infrequent, whereas mutton snapper and other species tagged moved more frequently. A total of 270,627 black grouper tag detections were recorded by the array between May 2008 and September 2012. The majority of black grouper detections were picked up by a single VR2 receiver, but vary substantially in frequency across seasons. Detection frequency for the 3 RH groupers was lowest during the summer period of July to September and highest during the period of October to March. Detection frequency drops drastically in early July for the largest fish (#21, 1069mm) and increases dramatically in early October, (sta.2, top figure), while detection of grouper #29 (sta. 2, 3, &48) is a more gradual decline, also beginning in early July, and like #21, frequency dramatically increases in October. Detection of grouper #23 at station 4 is more frequent during the same summer period without a dramatic decline, but detections do increase rapidly in early September. The pattern of detection frequency may suggests vertical movement, possibly indicating preference for cooler temperature and/or change in food availability. Figure The smaller DRTO grouper does not show an obvious pattern. To date, no black grouper have been detected moving across reserve boundaries. Four large grouper tagged in the TNER and RNA last October were the first large adult black grouper to be tagged outside of RH, and may be more likely to be detected by the array while moving to and from the shallower reefs, and possibly to RH during the winter/spring spawning period. The temporal and spatial movement of a balck grouper (# 56736) of 520.5 mm tagged in the DRTO since 2009. This grouper was detected 91 % of the time at station 45 and 9 % of the time at station 46 located at a distance of 661meters (Figure 4).

Future Work

Finfish

Our Tortugas Regional Array covering TNER, TSER, RNA, DRTO and open use areas of the FKNMS is continuously collecting data. We will continue to coordinate and share data with other regional telemetry projects (Pratt-Mote; Hart-USGS). These concurrent studies provide additional receiver coverage along the north side and central portion of the RNA.

Fishes that are tagged at the spawning aggregation site may be detected at stations established by these research groups and vice versa, providing invaluable data on the connectivity of this coral reef ecosystem. All VR2s were serviced and downloaded during May 2012 & October 2012. These data will include fish tagged in 2008, 2009, 2010, 2011 and 2012.

The results from our acoustic tagging in the Dry Tortugas TNER, TSER, RNA, DRTO have demonstrated the importance of adequately protecting spawning aggregation sites and nearby habitats simultaneously in order to ensure that FSAs can recover. By demonstrating fish connectivity between habitats inside and outside management zones in the Dry Tortugas, this research has provided critical information that has convinced State and Federal managers of the values of the reserves. Aggregation sites located in the Florida Keys may be at even more risk to over-exploitation than spawning sites in the Dry Tortugas due to the difference in levels of protection and fishing effort between these two locations. Inshore areas of the Florida Keys are more accessible to fishing, and to a larger coastal human population.

With limited funding available for next year, we proposed to conduct a similar study in waters of the Florida Keys proper. This study will measure snapper and grouper movement using

acoustic telemetry. Acoustic tags will be used to record fish movements utilizing an array of receivers located at aggregation sites and surrounding areas. Our initial focus area will be centered on the known and heavily fished aggregation sites from Key West to the Marquesas Keys. We plan to tag 15 fish during the peak of the spawning period (May-July) for snappers, 15 fish during the winter (January – April) for groupers, and 15 fish at other nearby locations.
Data collected by this project are vital for understanding the ecology and behavior of aggregate spawning species. The need for understanding these issues is particularly sensitive in locations where conflicting resource use generates controversy over management actions. This work will also improve our understanding of the connectivity between the spawning sites and the adjacent habitat. Therefore, linking the coral reef landscape structure, fish movement and the connectivity of the Florida Keys snapper and grouper spawning aggregations will provide a better understanding of the distribution and dynamics of these aggregations and the role they play in the health of the Florida Keys marine ecosystem. Ultimately, this project will help guide future management planning within the Florida Keys National Marine Sanctuary.
Data downloaded will yield time, location and depth, and will provide species-specific information on fish movement rates and spawning activities. This information will be analyzed to examine movement and core habitat utilization areas of snappers/groupers and determine long range movement between MPAs. All data collected will be entered into an FWC Access data base with statistical analyses using SPSS or SAS. Spatial and temporal data will be processed using Arcview GIS and Tracking Analysis software to examine movement patterns in association with habitats and MPA boundaries. A peer review manuscript using all the data downloaded up to September 2012 is currently underway.

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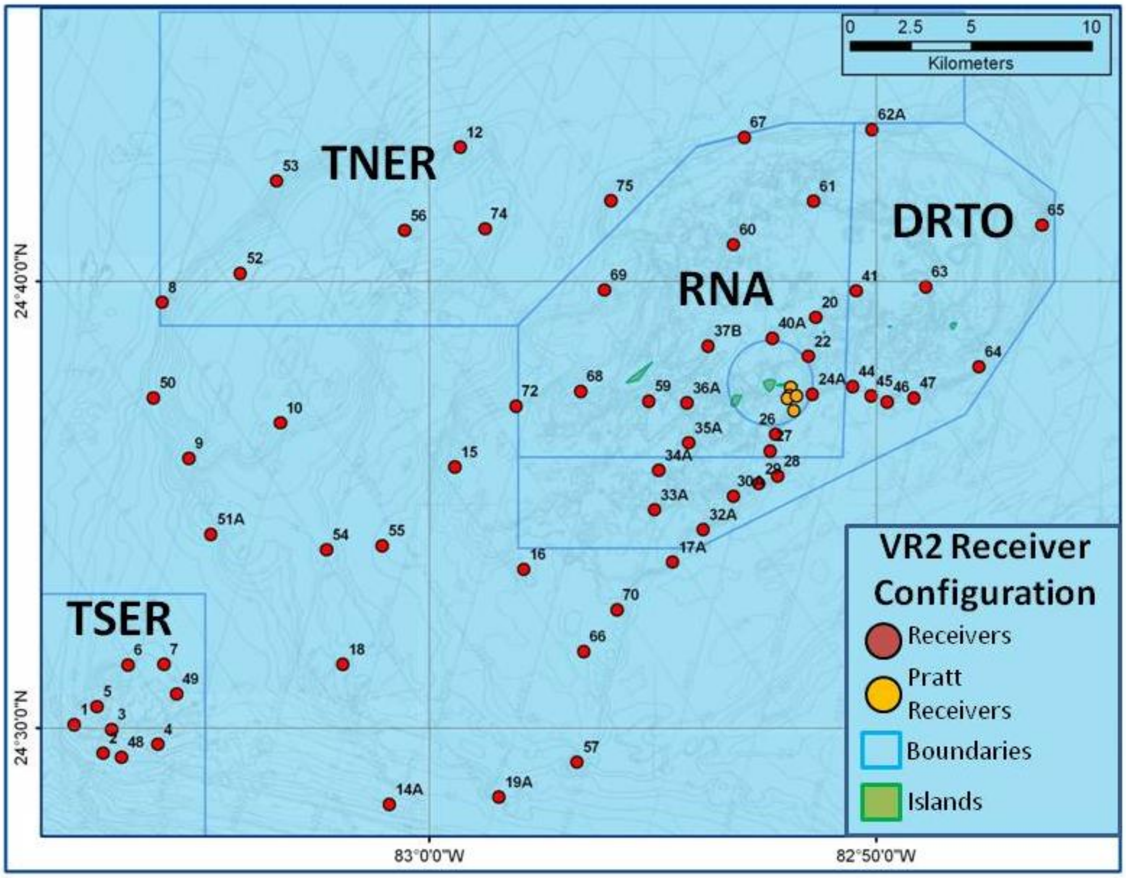

Figure 1. The TSER, TNER, DRTO and RNA create a network of no-take reserves that protect 600 km^2 of coral reef habitat in the Dry Tortugas. Location of FWC VR2 receivers are indicated for FY 2009. The FWC array is complemented by two collaborative telemetry projects: the Mote Marine Laboratory nurse shark project (PI: Dr. Wes Pratt) and USGS sea turtle project (PI: Dr. Kristen Hart).

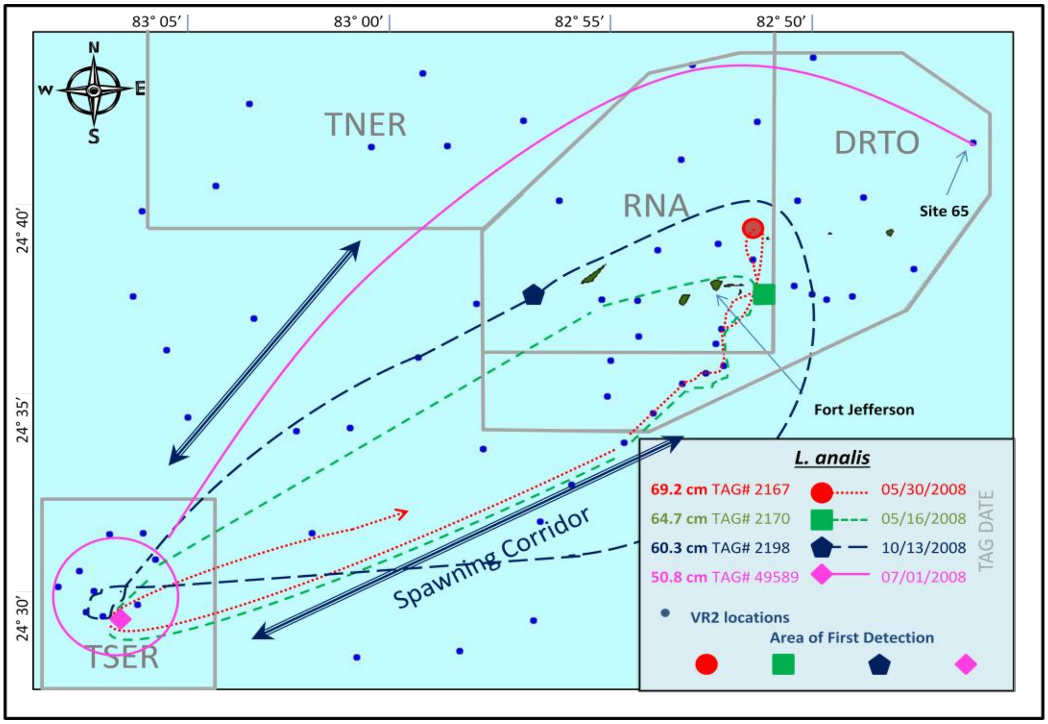

Figure 2. Tagging sites and preliminary spawning migratory movements of four mutton snapper in the Dry Tortugas.

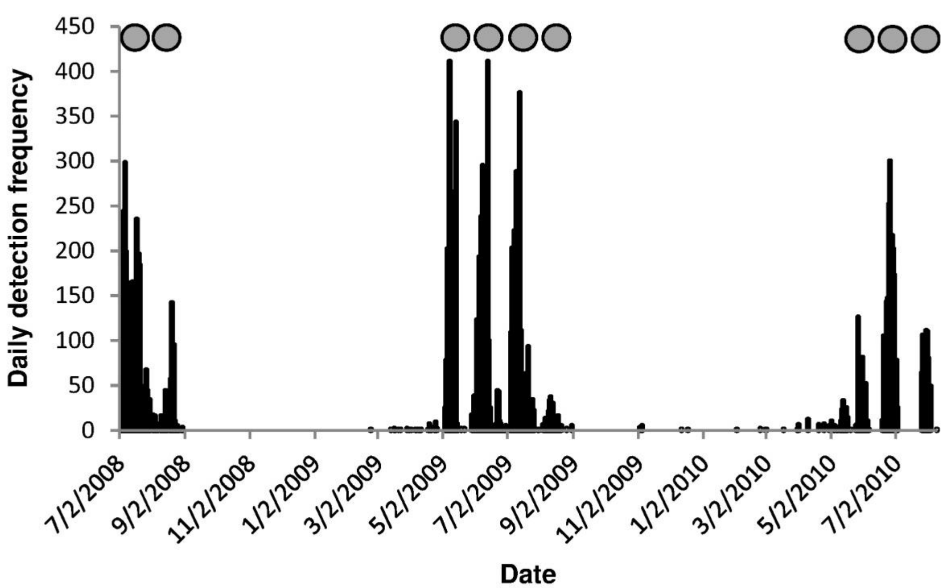

Figure 3. The daily frequency of mutton snapper transmitter detections from the south slope receiver in the Tortugas South Ecological Reserve on Riley’s Hump relative to the full moon phase.

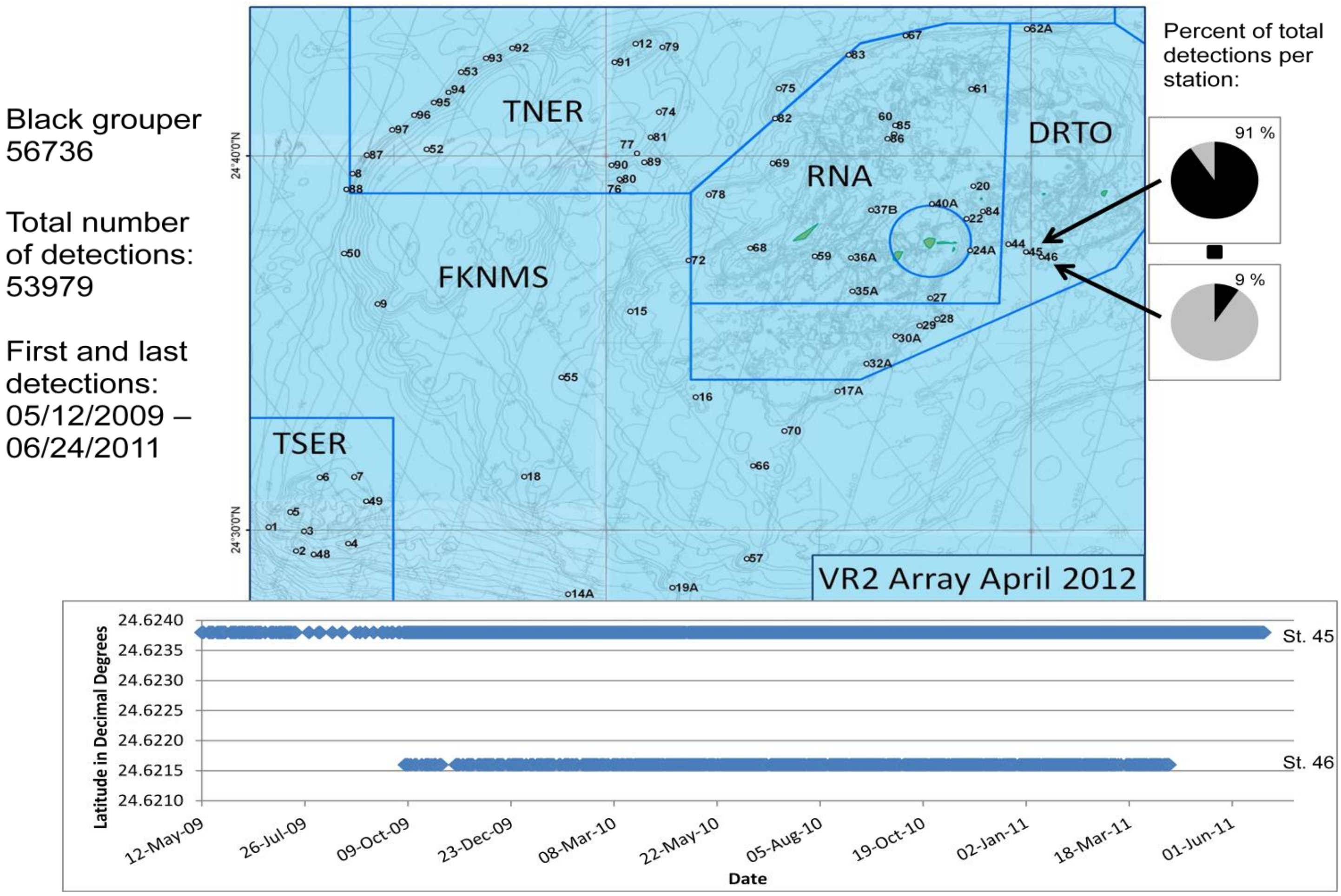

Figure 4. Percent detention and movement activity of a black grouper (#56736) tagged from 2009 to 2011 in the Dry Tortugas.

Table 1: Location of VR2 receivers in the Dry Tortugas region (September 2010). The management zone and cumulative number of detections is included for each station. Tortugas South Ecological Reserve (TSER), Tortugas North Ecological Reserve (TNER), Dry Tortugas National Park (DRTO), Research Natural Area (RNA), Florida Keys National Marine Sanctuary (FKNMS) and open waters (OPEN).

STATION	LATD	LATM	LOND	LONM	DEPTH (M)	ZONE	Number of Detections
1	24	30.077	83	7.943	2.4	TSER	2661
2	24	29.435	83	7.291	2.2	TSER	237747
3	24	29.968	83	7.103	2.2	TSER	6445
4	24	29.631	83	6.065	1.8	TSER	57796
5	24	30.478	83	7.431	2.3	TSER	29
6	24	31.408	83	6.732	2.1	TSER	1510
7	24	31.422	83	5.926	1.8	TSER	1142
8	24	39.520	83	5.966	1.8	TNER	143
9	24	36.036	83	5.371	1.6	OPEN	252
10	24	36.824	83	3.325	1.0	FKNMS	115
12	24	42.994	82	59.301	18.1	TNER	723
15	24	35.839	82	59.420	18.1	FKNMS	533
16	24	33.551	82	57.880	17.6	FKNMS	28
17A	24	33.710	82	54.547	16.6	FKNMS	495
18	24	31.424	83	1.927	0.6	FKNMS	77
19A	24	28.452	82	58.434	17.8	OPEN	3
20	24	39.185	82	51.348	15.7	RNA	127158
22	24	38.316	82	51.514	15.7	RNA	1594
26	24	36.572	82	52.246	15.9	RNA	4345
27	24	36.198	82	52.366	16.0	RNA	17425
28	24	35.638	82	52.200	15.9	DRTO	11133
29	24	35.462	82	52.619	16.0	DRTO	22402
41	24	39.778	82	50.450	15.4	DRTO	453
44	24	37.642	82	50.522	15.4	DRTO	6211
45	24	37.428	82	50.112	15.3	DRTO	32395
46	24	37.293	82	49.749	15.2	DRTO	9589
47	24	37.387	82	49.150	15.0	DRTO	761
48	24	29.346	83	6.878	2.1	TSER	56283
49	24	30.762	83	5.647	1.7	TSER	4543
50	24	37.387	83	6.165	1.9	OPEN	207
51A	24	34.332	83	4.879	1.5	OPEN	New Station
52	24	40.172	83	4.219	1.3	TNER	85
53	24	42.242	83	3.407	1.0	TNER	153
54	24	33.986	83	2.295	0.7	FKNMS	56
55	24	34.076	83	1.046	0.3	FKNMS	40
56	24	41.128	83	0.546	0.2	TNER	138
57	24	29.234	82	56.686	17.3	FKNMS	167
59	24	37.313	82	55.082	16.8	RNA	6005
60	24	40.814	82	53.187	16.2	RNA	42781

Table 1. (continued).

61	24	41.786	82	51.397	15.7	RNA	6539
62A	24	43.393	82	50.089	15.3	DRTO	895
63	24	39.872	82	48.885	14.9	DRTO	507
64	24	38.083	82	47.692	14.5	DRTO	1171
65	24	41.251	82	46.291	14.1	DRTO	3178
66	24	31.710	82	56.535	17.2	FKNMS	151
67	24	43.217	82	52.946	16.1	RNA	1328
68	24	37.533	82	56.605	17.3	RNA	10513
69	24	39.800	82	56.073	17.1	RNA	43
70	24	32.642	82	55.796	17.0	OPEN	132
24A	24	37.467	82	51.426	15.7	RNA	3925
30A	24	35.182	82	53.185	16.2	DRTO	9326
32A	24	34.441	82	53.863	16.4	DRTO	1305
33A	24	34.878	82	54.950	16.7	DRTO	80
34A	24	35.764	82	54.858	16.7	DRTO	308
35A	24	36.377	82	54.195	16.5	RNA	306798
36A	24	37.274	82	54.230	16.5	RNA	486
37B	24	38.549	82	53.753	16.4	RNA	330845
40A	24	38.719	82	52.321	15.9	RNA	549
14A	24	28.287	83	0.885	0.3	OPEN	1777
71	24	25.878	81	55.865	17.0	OPEN	1
72	24	37.202	82	58.051	17.69394	OPEN	92
73	24	25.291	82	26.511	8.080553	OPEN	70
74	24	41.168	82	58.748	17.90639	TNER	New Station
75	24	41.803	82	56.943	17.35623	TNER	New Station

Table 2. All acoustically tagged fish captured and released in the Dry Tortugas between May 2008 – September 2012.

Pinger code	Species	Date Tagged	Zone	Latitude	Longitude	Depth ft	TL inches	TL mm	Tag life days	Days of Tag Activity	% of Days Detected	Total Detections
27	*Epinephelus itajara*	6/13/2009	TNER	24 46.002	82 59.433	158	58.465	1485.0	480	480	0.00	0
2577	*Epinephelus itajara*	6/13/2009	TNER	24 46.002	82 59.433	158	77.835	1977.0	520	520	0.00	0
2576	*Epinephelus itajara*	6/1/2010	TSER	24 29.435	83 7.291	114	65.200	1656.1	520	415	10.84	2884
2572	*Epinephelus itajara*	6/1/2010	TSER	24 29.435	83 7.291	114	49.400	1254.8	520	415	23.86	3214
61856	*Epinephelus itajara*	1/6/2012	TNER	24.39.250	83.2.087	60	120.000	3048.0				
2153	*Epinephelus morio*	7/3/2008	TSER	24 29.367	83 6.863	85	27.000	685.8	150	150	99.33	51767
2166	*Epinephelus morio*	7/3/2008	TSER	24 29.543	83 7.349	88	23.000	584.2	470	470	2.55	56
56749	*Epinephelus morio*	5/8/2009	DRTO	24.6239	82.8312	34	22.500	571.5	1157	804	0.87	216
2154	*Epinephelus morio*	7/6/2008	TSER	24 29.432	83 7.288	123	16.000	406.4	150	151	100.00	63187
49585	*Epinephelus striatus*	7/5/2008	TSER	24 29.43	83 7.322	110	23.000	584.2	1160	1111	3.96	3715
52510	*Epinephelus striatus*	6/11/2009	TSER	24 29.438	83 7.298	105	26.000	660.4	1157	770	81.17	76278
56739	*Epinephelus striatus*	3/27/2011	OPEN	24.6449	-83.1030	75	31.000	787.4	1157	116	7.76	60
49603	*Haemulon plumieri*	5/30/2008	RNA	24.6209	82.8618	32	11.102	282.0	370	370	4.32	257
49601	*Haemulon plumieri*	5/19/2008	DRTO	24 38.553	82 48.909	21	11.378	289.0	370	370	0.00	0
49595	*Haemulon plumieri*	5/27/2008	RNA	24 37.758	82 52.981	33	9.961	253.0	370	370	0.00	0
49602	*Haemulon plumieri*	5/27/2008	RNA	24 37.75	82 52.949	15	10.709	272.0	370	370	0.00	0
2170	*Lutjanus analis*	5/16/2008	DRTO	24 35.583	82 52.687	32	25.500	647.7	470	470	38.94	11985
2175	*Lutjanus analis*	5/17/2008	DRTO	24 35.628	82 52.674	28	24.000	609.6	470	470	5.11	632
2176	*Lutjanus analis*	5/17/2008	DRTO	24 35.625	82 52.673	28	21.700	551.2	470	470	11.91	2238
2174	*Lutjanus analis*	5/22/2008	RNA	24 34.332	82 54.639	40	18.425	468.0	470	470	0.00	0
2185	*Lutjanus analis*	5/24/2008	DRTO	24 36.138	82 56.951	49	24.016	610.0	470	470	1.49	988
2168	*Lutjanus analis*	5/26/2008	RNA	24 36.384	82 54.141	15	22.283	566.0	470	470	80.85	443749
2167	*Lutjanus analis*	5/30/2008	RNA	24 38.853	82 51.419	24	27.244	692.0	470	470	64.89	127088
2177	*Lutjanus analis*	5/30/2008	RNA	24 38.853	82 51.419	24	25.394	645.0	470	470	62.13	7482
49589	*Lutjanus analis*	7/1/2008	TSER	24 29.475	83 7.264	95	20.000	508.0	1160	1115	2.78	958
49590	*Lutjanus analis*	7/1/2008	TSER	24 29.45	83 7.307	107	25.000	635.0	1160	1115	3.95	1099
49591	*Lutjanus analis*	7/1/2008	TSER	24 29.475	83 7.264	95	24.000	609.6	1160	1115	2.87	1933
13675/ 55	*Lutjanus analis*	7/2/2008	TSER	24 29.492	83 7.25	90	18.500	469.9	1160	1114	0.27	31

13674/54	*Lutjanus analis*	7/5/2008	TSER	24 29.432	83 7.288	120	18.000	457.2	1160	1111	1.80	405
13677/ 57	*Lutjanus analis*	7/5/2008	TSER	24 29.432	83 7.288	120	19.000	482.6	1160	1111	22.14	1900
13678/58	*Lutjanus analis*	7/5/2008	TSER	24 29.43	83 7.322	110	19.000	482.6	1160	1111	5.13	1509
13679/ 59	*Lutjanus analis*	7/5/2008	TSER	24 29.43	83 7.322	110	22.750	577.9	1160	1111	1.98	667
2198	*Lutjanus analis*	10/13/2008	RNA	24 37.437	82 56.51	14	23.750	603.3	820	820	20.85	4371
2200	*Lutjanus analis*	10/13/2008	RNA	24 37.437	82 56.51	14	23.250	590.6	820	820	0.37	213
2201	*Lutjanus analis*	10/13/2008	RNA	24 37.437	82 56.51	14	22.500	571.5	820	820	27.44	2768
49587	*Lutjanus analis*	10/13/2008	RNA	24 37.449	82 56.509	14	23.250	590.6	1160	1011	0.20	8
49588	*Lutjanus analis*	10/13/2008	RNA	24 37.437	82 56.51	14	28.250	717.6	1160	1011	4.95	1179
52502	*Lutjanus analis*	10/14/2008	DRTO	24 37.229	82 52.161	7	24.250	616.0	1157	1010	88.12	85379
52503	*Lutjanus analis*	10/15/2008	RNA	24 38.51	82 53.77	36	29.250	743.0	1157	1009	0.40	36
52504	*Lutjanus analis*	10/15/2008	RNA	24 38.51	82 53.77	36	27.750	704.9	1157	1009	43.11	120562
52505	*Lutjanus analis*	10/15/2008	RNA	24 38.51	82 53.77	36	21.000	533.4	1157	1009	98.12	519270
56742	*Lutjanus analis*	5/9/2009	RNA	24 38.693	82 51.074	28	20.500	520.7	1157	417	0.24	7
52507	*Lutjanus analis*	5/12/2009	RNA	24 37.55	82 56.207	15	24.000	609.6	1157	800	59.38	9790
52508	*Lutjanus analis*	5/12/2009	RNA	24 37.55	82 56.207	15	23.000	584.2	1157	800	37.63	2375
52509	*Lutjanus analis*	5/13/2009	RNA	24 38.687	82 51.08	31	25.500	647.7	1157	799	0.00	0
14805/131	*Lutjanus analis*	6/9/2009	TSER	24 29.399	83 7.24	112	24.000	609.6	1122	772	0.26	28
13676/ 56	*Lutjanus analis*	6/9/2009	TSER	24 29.438	83 7.298	105	25.000	635.0	1160	772	1.81	259
13680/ 60	*Lutjanus analis*	6/9/2009	TSER	24 29.438	83 7.298	105	25.000	635.0	1160	772	0.91	371
13682/ 62	*Lutjanus analis*	6/9/2009	TSER	24 29.438	83 7.298	105	28.000	711.2	1160	772	2.46	455
13683/ 63	*Lutjanus analis*	6/9/2009	TSER	24 29.399	83 7.24	112	24.000	609.6	1160	772	2.59	90
52515	*Lutjanus analis*	6/10/2009	TSER	24 29.438	83 7.298	105	24.000	609.6	1157	771	2.08	461
52511	*Lutjanus analis*	6/11/2009	TSER	24 29.458	83 7.384	120	18.500	469.9	1157	770	9.48	5035
52512	*Lutjanus analis*	6/11/2009	TSER	24 29.438	83 7.24	105	26.000	660.4	1157	770	0.39	29
52513	*Lutjanus analis*	6/11/2009	TSER	24 29.438	83 7.24	105	24.500	622.3	1157	770	0.13	19
52514	*Lutjanus analis*	6/11/2009	TSER	24 29.399	83 7.24	112	29.000	736.6	1157	770	32.73	7874
52516	*Lutjanus analis*	6/11/2009	TSER	24 29.438	83 7.24	105	23.000	584.2	1157	770	13.51	2695
13681/ 61	*Lutjanus analis*	6/11/2009	TSER	24 29.438	83 7.298	105	26.500	673.1	1160	770	0.13	1
56746	*Lutjanus analis*	6/12/2009	TSER	24 29.458	83 7.384	120	26.500	673.1	1157	769	0.39	35
56747	*Lutjanus analis*	6/12/2009	TSER	24 29.438	83 7.298	105	28.500	723.9	1157	769	1.04	60
56748	*Lutjanus analis*	6/12/2009	TSER	24 29.438	83 7.298	105	28.000	711.2	1157	769	3.51	809
56744	*Lutjanus analis*	9/25/2009	RNA	24 40.583	82 53.208	41	30.000	762.0	1157	664	21.69	1298
14806/132	*Lutjanus analis*	9/27/2009	RNA	24 37.868	82 55.025	15	30.000	762.0	1122	662	0.00	0
14802/128	*Lutjanus analis*	9/28/2009	RNA	24 40.281	82 53.343	39	22.250	565.2	1122	661	0.45	29

14803/129	*Lutjanus analis*	9/29/2009	RNA	24 37.401	82 56.574	14	29.000	736.6	1122	660	0.00	0
14804/130	*Lutjanus analis*	9/30/2009	RNA	24 37.446	82 56.564	19	24.500	622.3	1122	659	31.26	1295
61851	*Lutjanus analis*	5/30/2010	TSER	24 29.435	83 7.291	114	28.000	711.2	1157	417	97.60	68149
61849	*Lutjanus analis*	5/31/2010	TSER	24 29.435	83 7.291	114	28.000	711.2	1157	416	1.68	52
61853	*Lutjanus analis*	5/31/2010	TSER	24 29.435	83 7.291	114	29.500	749.3	1157	416	10.10	600
61852	*Lutjanus analis*	5/31/2010	TSER	24 29.435	83 7.291	114	27.000	685.8	1157	416	1.92	305
62115/6	*Lutjanus analis*	6/1/2010	TSER	24 29.435	83 7.291	114	35.300	896.6	1122	415	5.78	355
61848	*Lutjanus analis*	3/29/2011	DRTO	24.5925	82.8774	39	30.512	775.0	1157	114	57.02	2383
44321	*Lutjanus analis*	9/11/2012	OPEN	24.38.758	82.6.137	65	65.000	1524.0	1157	0	0.00	1160
2173	*Mycteroperca bonaci*	5/21/2008	RNA	24 39.027	82 51.022	35	23.976	609.0	470	470	0.00	0
2169	*Mycteroperca bonaci*	5/26/2008	RNA	24 36.38	82 54.05	20	17.244	438.0	470	470	1.49	259
2171	*Mycteroperca bonaci*	5/29/2008	DRTO	24 35.6	82 52.695	33	24.331	618.0	470	470	51.70	8836
2172	*Mycteroperca bonaci*	5/29/2008	RNA	24 36.418	82 54.156	28	21.575	548.0	470	470	9.15	2874
2184	*Mycteroperca bonaci*	5/30/2008	DRTO	24 35.824	82 52.199	30	22.126	562.0	470	470	1.28	146
2165	*Mycteroperca bonaci*	6/3/2008	DRTO	24 35.513	82 52.372	49	25.197	640.0	470	470	0.64	421
49586	*Mycteroperca bonaci*	10/11/2008	RNA	24 38.912	82 51.003	24	17.000	431.8	1160	1013	0.30	29
52506	*Mycteroperca bonaci*	10/14/2008	DRTO	24 37.229	82 52.161	5	26.250	666.8	1157	1010	73.56	30060
56751	*Mycteroperca bonaci*	5/8/2009	DRTO	24 37.433	82 49.872	34	21.000	533.4	1157	804	43.41	6743
56730	*Mycteroperca bonaci*	5/9/2009	DRTO	24 37.439	82 49.889	34	15.000	381.0	417	803	0.50	5
56731	*Mycteroperca bonaci*	5/9/2009	DRTO	24 37.439	82 49.889	34	18.500	469.9	417	803	0.00	0
56736	*Mycteroperca bonaci*	5/10/2009	DRTO	24 37.376	82 49.948	46	20.500	520.7	1157	802	86.16	53908
21	*Mycteroperca bonaci*	6/10/2009	TSER	24 29.529	83 7.239	90	42.087	1069.0	480	480	62.92	40190
23	*Mycteroperca bonaci*	6/10/2009	TSER	24 29.631	83 6.065	110	36.260	921.0	480	480	56.46	48075
28	*Mycteroperca bonaci*	6/10/2009	TSER	24 29.631	83 6.065	110	36.260	921.0	480	480	0.42	2
29	*Mycteroperca bonaci*	6/10/2009	TSER	24 29.399	83 7.24	112	38.386	975.0	480	480	51.25	29
56741	*Mycteroperca bonaci*	9/26/2009	RNA	24 40.583	82 53.21	42	18.000	457.2	1157	663	50.38	3494
61850	*Mycteroperca bonaci*	5/31/2010	TSER	24 29.435	83 7.291	114	29.000	736.6	1157	416	70.43	30220
61854	*Mycteroperca bonaci*	5/31/2010	TSER	24 29.435	83 7.291	114	26.500	673.1	1157	416	63.22	4078
24	*Mycteroperca bonaci*	6/1/2010	TSER	24 29.435	83 7.291	114	47.900	1216.7	480	415	10.36	846
22	*Mycteroperca bonaci*	6/1/2010	TSER	24 29.435	83 7.291	114	38.500	977.9	480	415	19.52	9734
2571	*Mycteroperca bonaci*	6/1/2010	TSER	24 29.435	83 7.291	114	42.100	1069.4	520	415	61.20	11675
2575	*Mycteroperca bonaci*	6/1/2010	TSER	24 29.435	83 7.291	114	42.100	1069.4	520	415	11.33	1178
62112/3	*Mycteroperca bonaci*	10/10/2010	RNA	24 38.478	82 51.092	26	24.000	609.6	1122	284	1.06	14
62111/2	*Mycteroperca bonaci*	10/10/2010	DRTO	24 38.922	82 50.992	21	22.500	571.5	1122	284	0.00	0
61858	*Mycteroperca bonaci*	10/11/2010	TNER	24 42.56	82 59.427	40	36.500	927.1	1157	283	0.00	0

61857	*Mycteroperca bonaci*	10/11/2010	TNER	24 43.055	82 59.513	60	28.000	711.2	1157	283	1.06	13
56737	*Mycteroperca bonaci*	3/27/2011	TNER	24.6624	-83.0974	79	25.984	660.0	1157	116	75.86	1995
56745	*Mycteroperca bonaci*	3/27/2011	OPEN	24.6547	-83.1014	77	25.984	660.0	1157	117	100.00	14547
56738	*Mycteroperca bonaci*	3/27/2011	TNER	24.6547	-83.1014	77	25.984	655.0	1157	116	4.31	296
61846	*Mycteroperca bonaci*	3/28/2011	TNER	24.7107	-82.9975	63	27.165	690.0	1157	115	2.61	12
56740	*Mycteroperca bonaci*	3/29/2011	OPEN	24.6315	-82.9679	52	21.654	550.0	1157	114	3.51	410
44318	*Mycteroperca bonaci*	1/9/2012	TNER	24.6638	-82.9925	84	69.000	1752.6	1248	214	64.95	139
44319	*Mycteroperca bonaci*	1/9/2012	TNER	24.6564	-82.9942	81	79.000	2006.6	1248	214	92.99	199
44320	*Mycteroperca bonaci*	1/10/2012	RNA	24.6418	-82.8521	57	79.000	2006.6	1248	213	93.90	200
33636	*Mycteroperca bonaci*	9/11/2012	TNER	24.6854	-82.0758	107	84.000	2133.6	1248	0	0.00	0
33642	*Mycteroperca bonaci*	9/12/2012	TNER	24.7174	-82.9925	68	66.000	1676.4	1248	0	0.00	0
33639	*Mycteroperca bonaci*	9/13/2012	RNA	24.6415	-82.8525	57	65.000	1651.0	1248	0	0.00	0
61855	*Mycteroperca venenosa*	10/11/2010	OPEN	24 39.392	83 6.016	72	28.000	711.2	1157	283	0.00	0
62113/4	*Mycteroperca microlepis*	1/9/2012	DRTO	24.5910	-82.8764	45	78.000	1981.2				
61860	*Mycteroperca microlepis*	1/7/2012	TNER	24.7174	-82.9925	62	73.000	1854.2				
49599	*Ocyurus chrysurus*	5/16/2008	DRTO	24 35.583	82 52.687	32	17.008	432.0	370	370	38.11	2129
49597	*Ocyurus chrysurus*	5/17/2008	DRTO	24 35.625	82 52.673	28	15.000	381.0	370	370	1.89	158
49598	*Ocyurus chrysurus*	5/17/2008	DRTO	24 35.625	82 52.673	28	17.008	432.0	370	370	6.49	148
49596	*Ocyurus chrysurus*	5/19/2008	DRTO	24 37.017	82 49.509	20	14.803	376.0	370	370	0.00	0
49600	*Ocyurus chrysurus*	5/19/2008	DRTO	24 37.017	82 49.509	20	15.787	401.0	470	470	0.21	1
52519	*Ocyurus chrysurus*	10/10/2008	DRTO	24 35.589	82 52.683	34	17.250	438.2	417	417	45.80	8736
52520	*Ocyurus chrysurus*	10/10/2008	DRTO	24 35.589	82 52.683	34	16.000	406.4	417	417	19.42	245
52521	*Ocyurus chrysurus*	10/10/2008	DRTO	24 35.589	82 52.683	34	17.500	444.5	417	417	12.47	190
52517	*Ocyurus chrysurus*	10/11/2008	RNA	24 38.912	82 51.003	24	16.500	419.1	417	417	0.00	0
52518	*Ocyurus chrysurus*	10/11/2008	RNA	24 38.912	82 51.003	24	20.250	514.4	417	417	2.88	601
56732	*Ocyurus chrysurus*	5/7/2009	DRTO	24 35.611	82 52.759	31	15.800	401.3	417	417	46.28	1284
56733	*Ocyurus chrysurus*	5/7/2009	DRTO	24 35.611	82 52.759	31	16.800	426.7	417	417	57.07	4057
56734	*Ocyurus chrysurus*	5/7/2009	DRTO	24 35.611	82 52.759	31	14.750	374.7	417	417	0.72	7
61844	*Ocyurus chrysurus*	9/24/2009	DRTO	24 35.509	82 52.628	39	17.300	440.0	417	417	47.48	4743
61845	*Ocyurus chrysurus*	9/24/2009	DRTO	24 35.509	82 52.628	39	16.000	406.4	417	417	95.20	15990
61843	*Ocyurus chrysurus*	9/25/2009	RNA	24 40.583	82 53.208	41	20.000	508.0	417	417	0.00	0
61841	*Ocyurus chrysurus*	9/25/2009	RNA	24 40.583	82 53.208	41	16.000	406.4	417	417	0.96	22
61842	*Ocyurus chrysurus*	9/25/2009	RNA	24 40.523	82 53.149	29	17.000	431.8	417	417	1.68	10
61842	*Ocyurus chrysurus*	9/25/2009	RNA	24 40.523	82 53.149	29	17.000	431.8	417	417	1.68	10

Table 2. All acoustically mutton snapper tagged captured and released in the Dry Tortugas between May 2008 – September 2012.

Pinger code	Species	Date	Zone	Depth (m)	TL (mm)	Tag life	Tag Stop	Total days detected	% Days detected	Days of Active tag
2170	*Lutjanus analis*	5/16/2008	DRTO	9.8	647.7	470	8/29/2009	183	38.94	470
2175	*Lutjanus analis*	5/17/2008	DRTO	8.5	609.6	470	8/30/2009	56	5.11	470
2176	*Lutjanus analis*	5/17/2008	DRTO	8.5	551.2	470	8/30/2009	24	11.91	470
2174	*Lutjanus analis*	5/22/2008	RNA	12.2	468.0	470	9/4/2009	0	0.00	470
2185	*Lutjanus analis*	5/24/2008	DRTO	14.9	610.0	470	9/6/2009	7	1.49	470
2168	*Lutjanus analis*	5/26/2008	RNA	4.6	566.0	470	9/8/2009	374	80.85	470
2167	*Lutjanus analis*	5/30/2008	RNA	7.3	692.0	470	9/12/2009	305	64.89	470
2177	*Lutjanus analis*	5/30/2008	RNA	7.3	645.0	470	9/12/2009	292	62.13	470
49589	*Lutjanus analis*	7/1/2008	TSER	29.0	508.0	1160	9/4/2011	44	2.78	1160
49590	*Lutjanus analis*	7/1/2008	TSER	32.6	635.0	1160	9/4/2011	31	3.95	1160
49591	*Lutjanus analis*	7/1/2008	TSER	29.0	609.6	1160	9/4/2011	31	2.87	1160
13675/ 55	*Lutjanus analis*	7/2/2008	TSER	27.5	469.9	1160	9/5/2011	3	0.27	1160
13674/54	*Lutjanus analis*	7/5/2008	TSER	36.6	457.2	1160	9/8/2011	277	1.80	1160
13677/ 57	*Lutjanus analis*	7/5/2008	TSER	36.6	482.6	1160	9/8/2011	70	22.14	1160
13678/58	*Lutjanus analis*	7/5/2008	TSER	33.6	482.6	1160	9/8/2011	22	5.13	1160
13679/ 59	*Lutjanus analis*	7/5/2008	TSER	33.6	577.9	1160	9/8/2011	20	1.98	1160
2198	*Lutjanus analis*	10/13/2008	RNA	4.3	603.3	820	1/11/2011	225	20.85	820
2200	*Lutjanus analis*	10/13/2008	RNA	4.3	590.6	820	1/11/2011	171	0.37	820
2201	*Lutjanus analis*	10/13/2008	RNA	4.3	571.5	820	1/11/2011	50	27.44	1160
49587	*Lutjanus analis*	10/13/2008	RNA	4.3	590.6	1160	12/17/2011	3	0.20	820
49588	*Lutjanus analis*	10/13/2008	RNA	4.3	717.6	1160	12/17/2011	2	4.95	1160
52502	*Lutjanus analis*	10/14/2008	DRTO	2.1	616.0	1157	12/15/2011	908	88.12	1157
52503	*Lutjanus analis*	10/15/2008	RNA	11.0	743.0	1157	12/16/2011	998	0.40	1157
52504	*Lutjanus analis*	10/15/2008	RNA	11.0	704.9	1157	12/16/2011	435	43.11	1157
52505	*Lutjanus analis*	10/15/2008	RNA	11.0	533.4	1157	12/16/2011	4	98.12	1157
56742	*Lutjanus analis*	5/9/2009	RNA	8.5	520.7	1157	7/9/2012	163	0.24	1157
52507	*Lutjanus analis*	5/12/2009	RNA	4.6	609.6	1157	7/12/2012	501	59.38	1157
52508	*Lutjanus analis*	5/12/2009	RNA	4.6	584.2	1157	7/12/2012	308	37.63	1157
52509	*Lutjanus analis*	5/13/2009	RNA	9.5	647.7	1157	7/13/2012	51	0.00	1157
131/14805	*Lutjanus analis*	6/9/2009	TSER	34.2	609.6	1160	8/12/2012	20	0.26	1160

13676/ 56	*Lutjanus analis*	6/9/2009	TSER	32.0	635.0	1160	8/12/2012	19	1.81	1160
13680/ 60	*Lutjanus analis*	6/9/2009	TSER	32.0	635.0	1160	8/12/2012	14	0.91	1160
13682/ 62	*Lutjanus analis*	6/9/2009	TSER	32.0	711.2	1160	8/12/2012	7	2.46	1160
13683/ 63	*Lutjanus analis*	6/9/2009	TSER	34.2	609.6	1160	8/12/2012	2	2.59	1160
52515	*Lutjanus analis*	6/10/2009	TSER	32.0	609.6	1157	8/10/2012	16	2.08	1157
52511	*Lutjanus analis*	6/11/2009	TSER	36.6	469.9	1157	8/11/2012	317	9.48	1157
52512	*Lutjanus analis*	6/11/2009	TSER	32.0	660.4	1157	8/11/2012	104	0.39	1157
52513	*Lutjanus analis*	6/11/2009	TSER	32.0	622.3	1157	8/11/2012	73	0.13	1157
52514	*Lutjanus analis*	6/11/2009	TSER	34.2	736.6	1157	8/11/2012	3	32.73	1157
52516	*Lutjanus analis*	6/11/2009	TSER	32.0	584.2	1157	8/11/2012	1	13.51	1157
13681/ 61	*Lutjanus analis*	6/11/2009	TSER	32.0	673.1	1160	8/14/2012	1	0.13	1160
56746	*Lutjanus analis*	6/12/2009	TSER	36.6	673.1	1157	8/12/2012	27	0.39	1157
56747	*Lutjanus analis*	6/12/2009	TSER	32.0	723.9	1157	8/12/2012	8	1.04	1157
56748	*Lutjanus analis*	6/12/2009	TSER	32.0	711.2	1157	8/12/2012	3	3.51	1157
56744	*Lutjanus analis*	9/25/2009		12.5	762.0	1157	11/25/2012	276	21.69	1052
14806/132	*Lutjanus analis*	9/27/2009		4.6	762.0	1122	10/23/2012	0	0.00	1122
14802/128	*Lutjanus analis*	9/28/2009		11.9	565.2	1122	10/24/2012	3	0.45	1049
14803/129	*Lutjanus analis*	9/29/2009		4.3	736.6	1122	10/25/2012	0	0.00	1048
14804/130	*Lutjanus analis*	9/30/2009		5.8	622.3	1122	10/26/2012	230	31.26	1047
61851	*Lutjanus analis*	5/30/2010		34.8	711.2	1157	7/30/2013	788	97.60	805
61849	*Lutjanus analis*	5/31/2010		34.8	711.2	1157	7/31/2013	64	1.68	804
61853	*Lutjanus analis*	5/31/2010		34.8	749.3	1157	7/31/2013	56	10.10	804
61852	*Lutjanus analis*	5/31/2010		34.8	685.8	1157	7/31/2013	7	1.92	804
62115/6	*Lutjanus analis*	6/1/2010		34.8	896.6	1157	8/1/2013	99	5.78	803
61848	*Lutjanus analis*	3/29/2011		11.9	775.0	1157	5/29/2014	152	57.02	502
44321	*Lutjanus analis*	9/11/2012	OPEN	19.8	1524.0	1248	2/11/2016	0	0.00	1160

Table 3. All acoustically black grouper tagged captured and released in the Dry Tortugas between May 2008 – September 2012.

Pinger code	Species	Date Tagged	Zone	Depth (m)	TL (mm)	Gender	Tag life	Tag Stop	Total days detected	%Days detected	Days of active tag
2173	*Mycteroperca bonaci*	5/21/2008	RNA	35	609.0		470	9/3/2009	0	0.00	470
2169	*Mycteroperca bonaci*	5/26/2008	RNA	20	438.0		470	9/8/2009	64	13.62	470
2171	*Mycteroperca bonaci*	5/29/2008	DRTO	33	618.0		470	9/11/2009	243	51.70	470
2172	*Mycteroperca bonaci*	5/29/2008	RNA	28	548.0		470	9/11/2009	44	9.36	470
2184	*Mycteroperca bonaci*	5/30/2008	DRTO	30	562.0		470	9/12/2009	6	1.28	470
2165	*Mycteroperca bonaci*	6/3/2008	DRTO	49	640.0		470	9/16/2009	3	0.64	470
49586	*Mycteroperca bonaci*	10/11/2008	RNA	24	431.8		1160	12/15/2011	3	0.26	1160
52506	*Mycteroperca bonaci*	10/14/2008	DRTO	5	666.8		1157	12/15/2011	178	15.38	1157
56751	*Mycteroperca bonaci*	5/8/2009	DRTO	34	533.4		1157	7/8/2012	459	39.67	1157
56730	*Mycteroperca bonaci*	5/9/2009	DRTO	34	381.0		417	6/30/2010	4	0.96	417
56731	*Mycteroperca bonaci*	5/9/2009	DRTO	34	469.9		417	6/30/2010	0	0.00	417
56736	*Mycteroperca bonaci*	5/10/2009	DRTO	46	520.7		1157	7/10/2012	692	59.81	1157
21	*Mycteroperca bonaci*	6/10/2009	TSER	90	1069.0		450	9/3/2010	302	67.11	450
23	*Mycteroperca bonaci*	6/10/2009	TSER	110	921.0		450	9/3/2010	272	60.44	450
28	*Mycteroperca bonaci*	6/10/2009	TSER	110	921.0		450	9/3/2010	2	0.44	450
29	*Mycteroperca bonaci*	6/10/2009	TSER	112	975.0		450	9/3/2010	246	54.67	450
56741	*Mycteroperca bonaci*	9/26/2009		42	457.2		1157	11/26/2012	539	51.38	1049
61850	*Mycteroperca bonaci*	5/31/2010		114	736.6	F	1157	7/31/2013	826	100.00	826
61854	*Mycteroperca bonaci*	5/31/2010		114	673.1	F?	1157	7/31/2013	697	84.38	826
24	*Mycteroperca bonaci*	6/1/2010		114	1216.7	UNK	450	8/25/2011	43	9.56	450
22	*Mycteroperca bonaci*	6/1/2010		114	977.9	UNK	450	8/25/2011	83	18.44	450
2571	*Mycteroperca bonaci*	6/1/2010		114	1069.3	UNK		6/1/2010	254	48.85	520
2575	*Mycteroperca bonaci*	6/1/2010		114	1069.3	UNK		6/1/2010	50	9.62	520
62112	*Mycteroperca bonaci*	10/10/2010		26	609.6	UKN	1157	12/10/2013	3	0.45	670
62111	*Mycteroperca bonaci*	10/10/2010		21	571.5	UKN	1157	12/10/2013	88	13.13	670
61858	*Mycteroperca bonaci*	10/11/2010		40	927.1	UKN	1157	12/11/2013	0	0.00	669
61857	*Mycteroperca bonaci*	10/11/2010		60	711.2	UKN	1157	12/11/2013	3	0.45	669
56737	*Mycteroperca bonaci*	3/27/2011		79	660.0	UNK	1157	5/27/2014	185	36.85	502
56745	*Mycteroperca bonaci*	3/27/2011		77	660.0	UNK	1157	5/27/2014	154	30.68	502
56738	*Mycteroperca bonaci*	3/27/2011		77	655.0	UNK	1157	5/27/2014	5	1.00	502

61846	*Mycteroperca bonaci*	3/28/2011	63	690.0	UNK	1157	5/28/2014	3	0.60	501
56740	*Mycteroperca bonaci*	3/29/2011	52	550.0	UNK	1157	5/29/2014	4	0.80	500
44318	*Mycteroperca bonaci*	1/9/2012	84	1752.6		1248	6/10/2015	139	64.95	214
44319	*Mycteroperca bonaci*	1/9/2012	81	2006.6		1248	6/10/2015	199	92.99	214
44320	*Mycteroperca bonaci*	1/10/2012	57	2006.6		1248	6/11/2015	200	93.90	213
33636	*Mycteroperca bonaci*	9/11/2012	107	2133.6			9/11/2012	0	0.00	0
33642	*Mycteroperca bonaci*	9/12/2012	68	1676.4			9/12/2012	0	0.00	0
33639	*Mycteroperca bonaci*	9/13/2012	57	1651.0			9/13/2012	0	0.00	0

WESTERN SAMBO ECOLOGICAL RESERVE – LOBSTER

Introduction

Lobsters were re-surveyed in WSER, Eastern Sambo Special Use Area (ESSUA), Middle Sambo, and Pelican Shoal during 2012. Both WSER and ESSUA are no-take reserves and Middle Sambo and Pelican Shoal are open to fishing. Additionally, for a third year we surveyed lobsters in the outlier reef just beyond the WSER boundaries, where lobsters appear to release their eggs (Bertelsen in press) To determine lobster size, sex, and abundance inside FKNMS marine reserve zones and their exploited reference areas, we used size distribution surveys and 500 m^2 belt transect surveys during the closed fishing season. Sampling was designed to test the hypothesis that currently established no-take zones sufficiently protect lobsters so that lobsters in these areas become larger and more abundant than those in unprotected areas.

Methods

Lobster - Size distribution surveys

Four hundred thirty-seven lobsters were captured for size structure estimates (Tables 4 and 5). We measured lobsters and examined them for molt condition, sex, reproductive status (females), and evidence of disease. We stratified sampling by habitat type because we expected each habitat to shelter a different size range and sex ratio of spiny lobsters (Hunt et al., 1991). Strata included reef crest, patch reef, and outlier reef. We attempted to capture at least 50 spiny lobsters per stratum in the reserves and at reference areas.

Lobster Monitoring - Area Surveys

To compare abundance, we searched for lobsters in reserves (WSER and ESSUA) and reference areas (Pelican Shoal and Middle Sambo) using area-based surveys. Divers counted all lobsters in 190 transects (500 m2) on the reef crest, outlier reef (no reference area), and patch reefs of reserve and reference areas (Table 6). Divers searched a 5 m wide area on each side of a 50 m tape and replicated this measure at each site. Where possible, we attempted to select sites we had not yet sampled, including sites on the margin of areas marked as reef on habitat maps, in an effort to sample the complete area where lobsters may reside.

Lobster Monitoring - Statistics

Mean size of lobsters from the reef crest was compared using ANOVA. Size data on males and females were separated to control for the different ratios of males to females in our samples, since females are often more abundant and males are usually larger. The mean size for both males and females on the patch reef sites were compared with independent samples t-tests. We did not include the outlier reef since it did not have a comparable reference area. Differences in lobster size between habitat types were compared using ANOVA, a Mann-Whitney test, and a t-test. Tests of sexual dimorphism (male - female size) for the reef crest comparing reserves to reference areas were conducted using a multiple t-test assuming unequal variance due to the unequal sample sizes, however, where samples passed the Levene’s Test for equality of variance, equal variances were assumed. Differences in lobster density between regions were evaluated using ANOVA and independent samples t-test. Again, we did not include the outlier reef, since it did not have a reference area. Differences in lobster density between habitat types were evaluated using a Mann-Whitney test, and Kruskal-Wallis test.

Results and discussion

Lobster - Inside and outside the Marine Reserves

There were no significant differences in size of either male or female lobsters from the reef crest regions (Pelican Shoal, WSER, Middle Sambo and ESSUA) (Table 5, males: ANOVA, d.f. = 3, F = 1.29, P = 0.281, females: ANOVA, d.f. = 3, F = 1.53, P = 0.208).
For patch reefs there was a difference in the size of females (*t* test, d.f. = 60, *t* = -3.750, *P* =0.00), and males between regions (*t* test, d.f. = 62, *t* = -5.449, *P* =0.000). Males and females from patch reefs in WSER were larger than those from patch reefs near Pelican Shoal. Typically lobsters from WSER (sometimes Eastern) are larger than lobsters from Pelican Shoal. This year's lobsters were exceptionally small. Smaller mean lobster size could indicate that this year was a particularly good recruitment year and there was an influx of lobsters. However, the low densities and infrequent lobsters larger than 100 mm carapace length (CL) suggest that this year's lobsters are just small. While this could mean that some large lobsters have left the reserves, the lobsters may also be differently spatially distributed this year; more than 15% of lobsters in WSER patches were larger than 100 mm CL, whereas no more than 5% of the lobsters were larger than 100 mm CL at every other location.

Lobster- habitat type

There were significant differences in lobster size between habitat types for male lobsters at Pelican Shoal (Table 5, males: *t* test, d.f. = 61, *t* = 2.855, *P* =0.006) but no differences in size between habitat types for females (*Mann-Whitney Test*, =0.419). Male lobsters on the Pelican Shoal reef crest were larger than those on nearby patches. There were differences in size of lobster between habitat types for male and female lobsters at WSER (males: ANOVA, d.f. = 2, F = 7.99, P = 0.001, females: ANOVA, d.f. = 2, F = 4.09, P = 0.019) Males lobsters from the patches were significantly larger than males from the reef crest or outlier reef. Female lobsters from patches were significantly larger than females from the outlier reef. Overall, it appears that lobsters residing on patch reefs in WSER were rather large.

Lobster - Sexual size dimorphism

A comparison of mean carapace length (CL) between male and female lobsters is presented in Table 7. A functional marine protected area should retain mature animals, and since adult male lobsters are likely growing faster than adult female lobsters (Lipcius and Herrnkind 1987, Bertelsen et al. 2004), significant differences in size between males and females should be an indicator of an effective marine protected area. The average size difference between sexes for the past 6 years indicates sexual size dimorphism is generally greatest in the large reserve, WSER, and decreases with distance from WSER (Maxwell et al. 2010). This year there were significant differences in size between sexes at Pelican Shoal reef crest, Middle Sambo reef, and Western Sambo patches. Unlike most years, the males were not bigger in the reef crest reserves and were, in fact, slightly smaller at Eastern Sambo. These results are unusual, and again could be explained by an unusual spatial distribution of lobsters.

Lobster - Density
Lobster densities per 500 m2 transect are reported in Table 8. There were no differences in density of lobsters between any of the reef crest locations (Pelican Shoal, WSER, Middle Sambo and Eastern Sambo) (ANOVA, d.f. = 3, F = 2.500, P = 0.063) or patch reef locations (Pelican Shoal and WSER) (*t* test, d.f. = 38, *t* = 0.562, *P* =0.577). There were also no significant differences in density between habitat types at Pelican Shoal (*Mann-Whitney Test*, =0.417), but there were significant differences between habitat types at WSER. (Kruskal Wallis, P = 0.043). There were significantly more lobsters on WSER patch reefs than at the outlier reef. Densities at the reef crest were lower this year compared to average mean densities between 2004-2010, whereas the density of lobsters on patch reefs this year was greater than average mean density between 2004-2010. As such, lobsters appeared to be distributed across habitat strata differently than most years.

Lobster – Outlier reef
Similar to the previous two years, the sex ratio at the outlier reef was more skewed towards females than at other locations (Table 4). This result is consistent with FWC's observations of lobsters tagged with sonic tags. The outlier reef appears to be where a number of females go to release their eggs (Bertelsen et al. 2012). The influx of migrating females could account for the skewed sex ratio during the breeding season (Mar-Sept).

Future Work
Lobster
With no funding next year, we will not be able to continue the annual lobster abundance and size structure surveys in and adjacent to WSER.

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Spiny lobster marine reserves team

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Table 4. 2012 Number of lobsters collected for size distribution analysis by region and habitat (males/females).

	Habitat			
Region **(Bold = reserve)**	Reef crest	Outlier reef	Patch reef	Total
Pelican Shoal	69 (25/44)		69 (38/31)	138(63/75)
Eastern Sambo (SUA)	69 (27/42)			69 (27/42)
Middle Sambo	55(16/39)			55 (16/39)
Western Sambo (ER)	67 (24/43)		57 (26/31)	124(50/74)
Western Sambo		51 (12/39)		51 (12/39)
Total	260(92/168)	51 (12/39)	126(64/62)	437(168/269)

Table 5. 2012 Mean size (mm carapace length) of lobster by sex, habitat, and region.

Habitat	Region (**Bold = reserve**)	Males	Females	Overall
		Mean ±SD	Mean ±SD	Mean ±SD
Reef crest	Pelican Shoal	82.1±12.7	74.3±7.1	77.1±10.2
	Eastern Sambo SUA	76.9±15.2	77.7±8.5	77.4±11.5
	Middle Sambo	82.9±9.6	77.8±7.9	79.3±8.7
	Western Sambo ER	77.5±11.6	77.0±10.4	77.2±10.8
Patch reef	Pelican Shoal	71.8±14.7	71.5±10.4	71.7±12.9
	Western Sambo ER	90.8±11.9	82.2±12.0	86.1±12.6
Outlier reef	Western Samb o	78.1±16.2	75.3±8.6	75.9±10.7
	Overall	79.4±14.5	76.5±9.6	77.6±11.8

Table 6. 2012 Number of transect (500m2) surveys conducted by region (note: Patch reef transects were stratified equally into 10 top and 10 side transects).

		Habitat		
Region **(Bold = reserve)**	Reef crest	Outlier reef	Patch reef	Total
Pelican Shoal	40		20	60
Eastern Sambo (SUA)	19			19
Middle Sambo	20			20
Western Sambo (ER)	41		20	61
Western Sambo		30		30
Total	120	30	40	190

Table 7. Results of multiple t-tests comparing mean size (carapace length) of male and female lobsters. Although not all of the results are significant, except for Eastern Sambo the mean male size was larger than the mean female size.

Location(**bold = reserve**)	t	df	Sig. (2 tailed)	Mean difference
Pelican Shoal reef crest	2.83	32.65	0.008	7.8 mm CL
Eastern Sambo SUA reef crest	-0.25	36.48	0.801	-0.8 mm CL
Middle Sambo reef crest	2.04	53.00	0.047	5.1 mm CL
Western Sambo ER reef crest	0.19	65.00	0.852	0.5 mm CL
Pelican Shoal patch	0.13	65.76	0.898	0.4 mm CL
Western Sambo ER patch	2.69	55.00	0.009	8.6 mm CL
Western Sambo outlier reef	0.58	12.96	0.575	2.8 mm CL

Table 8. Number of lobsters per 500m2.

Region **(Bold = reserve)**	Habitat			
	Reef crest Mean±SD	Outlier reef Mean±SD	Patch reef Mean±SD	Overall Mean±SD
Pelican Shoal	1.73±1.95		3.60±8.45	2.33±5.09
Eastern Sambo (SUA)	3.63±3.64			3.63±3.64
Middle Sambo	1.95±2.01			1.95±2.01
Western Sambo (ER)	1.71±3.22		2.45±3.50	1.95±3.30
Western Sambo		0.57±0.73		0.57±0.73
Total	2.06±2.80	0.57±0.73	3.03±6.41	2.02±3.74

Outcomes (Publications)

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Characterizing daily movements, nomadic movements, and reproductive migrations of *Panulirus argus* around the Western Sambo Ecological Reserve (Florida, USA) using acoustic telemetry

Rodney D. Bertelsen

Abstract

The movements of the Caribbean spiny lobster (Panulirus argus) were studied in three subregions, (1) patch reefs, (2) forereef, and (3) outlier reef, in and around the Western Sambo Ecological Reserve (WSER) (Florida, USA) using acoustic tags and receivers. The studies took place from the June 2003 through July 2007 and involved various receiver deployments such as tracking grids and emigration rings designed to track relatively short daily movements and long distance (> 1 km) movements. Daily movements were found to be highly repetitive in some individual lobsters in both the patch reef and the forereef. Some forereef lobsters shifted foraging preference between the forereef itself (63%), a shallow back reef area(10%), reef base(9%), and a deeper reef base area (4%), with undetermined making up the remainder.
Approximately one-third of the patch reef resident lobsters exhibited significantly enhanced nocturnal movements during periods of low or no lunar illumination. Twenty-two nomadic movements were detected and occurred throughout the year and included individuals that moved between Western Sambo Ecological Reserve and the outlier reef south of the reserve.
Lateral movements detected along the forereef were exhibited by only a few male lobsters.
Reproductive migrations by reproductively active female lobsters were observed in all subregions. These movements are characterized by a sudden rapid southward move initiated near

midnight. For patch reef and forereef females, the destination is 1 deep water to the south of the forereef. Outlier reef females moved to deeper water to their south. Up to three reproductive migrations were conducted at a median interval of 25 days (16 multiple trips detected). With respect to one of WSER's stated management goals, i.e., to protect life histories, lobster movements have shown that the outlier reef subregion, located 1 km south of the southern WSER border, is integral to the spiny lobster life history and should be considered for inclusion into WSER.

Keywords: Acoustic telemetry; *Panulirus argus*; Movement; Ecological reserve; Nomadic; Migration

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(http://www.sciencedirect.com/science/article/pii/S0165783612003529)

Appendix 1.

Tortugas Cruise Report for 2012

A follow up to the 2011 performance evaluation of marine zoning in the Florida Keys National Marine Sanctuary: Assessment of Riley's Hump deep ecosystem by *in situ* and remote sampling techniques

INTRODUCTION

A research cruise was taken aboard NOAA's Nancy Foster to the Dry Tortugas from July 22nd to August 9th in 2012 as a continuation of the 2011 study of the Riley's Hump ecosystem. Scientists from the Florida Fish and Wildlife Conservation Commission (FWC) and NOAA conducted surveys of potential spawning aggregations sites around Riley's Hump (RH) as well as replacing VR2 acoustic receivers. An additional research cruise was taken the next month on September 1st and 2nd aboard NOAA's Peter Gladding law enforcement vessel from the Florida Key's National Marine Sanctuary.

Under the direction of Chief Scientist Scott Donahue, Alejandro Acosta and Danielle Morley (FWRI), a team of shallow divers (David Eaken, Paul Barbera, Ben Binder, Jeffrey Renchen, Bill Sympson, Scott Donahue, Hatsue Bailey, Sarah Fangman, and Sean Morton) downloaded VR2 receivers and conducted reef visual censuses (RVCs) over various locations of the Dry Tortugas. After arriving in the Riley's Hump area, the Nancy Foster's EK-60 echo sounder was used early mornings to pinpoint locations of high fish concentrations around specific RH features selected by Paul Barbera. Once the coordinates were recorded, either divers or the ROV/drop camera were deployed to the location in order to verify the aggregations of fish. Ben Binder, Jeffrey Renchen, and Alejandro Acosta deployed and conducted the remotely operated vehicle (ROV) and drop camera operations to record fish aggregations that were too deep for diver observation (>110 ft). David Eaken and Scott Donahue were the dive safety officers aboard the ship.

OBJECTIVES

1) Evaluate the multi-species aggregation sites around Riley's Hump by documenting the presence and abundance of commercially important fish within the area.
   - a) Conduct visual censuses of fish clusters along the edge of Riley's Hump detected by the Nancy Foster's split-beam sonar systems.
   - b) In instances of depths greater than 110 ft, conduct remote sampling unit operations using the ROV or drop camera to record video footage of commercially important fish species.

2) Download acoustic receiver (VR2) data, replace batteries, and clean VR2 stations. Divers were used to swap receivers and clean the VR2 stands throughout the Dry Tortugas area.

METHODS

Table 1. Scientific crew that participated in diving during the August 2012 Nancy Foster trip

Name	Position	Email	Phone	Agency
Alejandro Acosta	Chief Scientist	Alejandro.Acosta@myfwc.com	305-289-2330	FWC/FWRI
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STUDY AREA

The Tortugas Ecological Reserves (TSER & TNER) and the Research Natural Area (RNA) are no-take marine reserves located adjacent to and within the Dry Tortugas National Park (DRTO), 70 miles west of Key West, FL, USA (Figure 1). These reserves (600 km2) protect a variety of habitat including: shallow sea grass and hard bottom nursery grounds, Riley's Hump (RH) (30 m), an offshore reef fish spawning aggregation site, and deepwater habitat > 600 m. This network of reserves is designed to enhance sustainability and biodiversity throughout the Tortugas and the Florida Keys coral reef ecosystem by creating a refuge for numerous exploited fishery resources, including snappers and groupers.

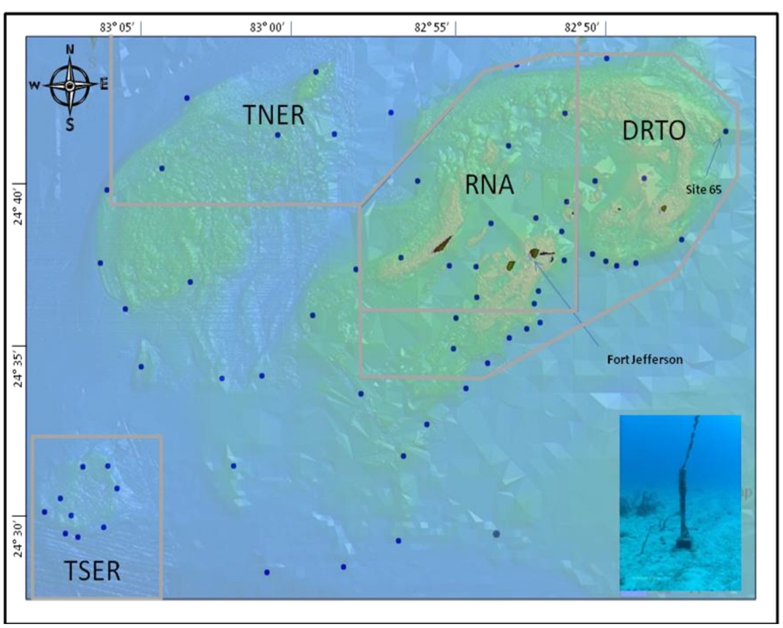

Figure 1. Location of Acoustic Receivers (VR2) in the Dry Tortugas Region

SAMPLING PLATFORM

The NOAA Nancy Foster is a 187 ft research vessel that was originally a NAVY yard torpedo test craft. It primarily operates along the Atlantic and Gulf Coast and the Caribbean. The Nancy Foster is run by the NOAA core and is designed to be a floating research platform capable of supporting a variety of scientific studies. Additionally, the ship is fitted with four small boat vessels that can be launched for shallow water operations.

Figure 2. The NOAA Nancy Foster

The Peter Gladding is a 57 ft enforcement catamaran that patrols the Florida Keys National Marine Sanctuary. The ship provides a research platform to conduct dive or remote sensing unit operations.

Figure 3. The P/V Peter Gladding (http://sanctuaries.noaa.gov/missions/vessels/vessel4.html)

REMOTELY SENSING EQUIPMENT

The high quality videos from the ROV and drop camera were used to estimate the distribution and abundance of fish at each study site.

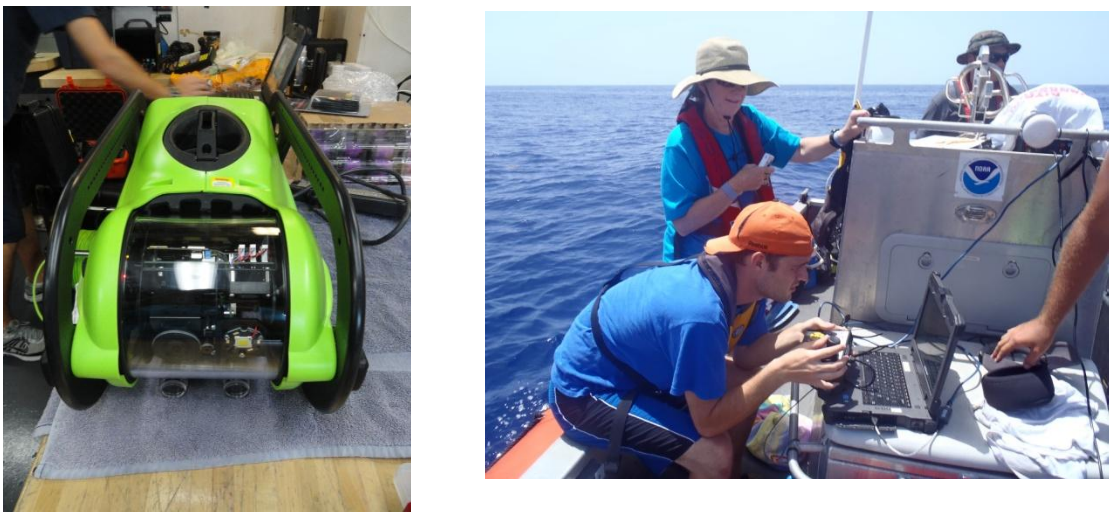

Figure 4. FWC's Seabotix ROV (left) and operation console (right)

PRELIMINARY RESULTS

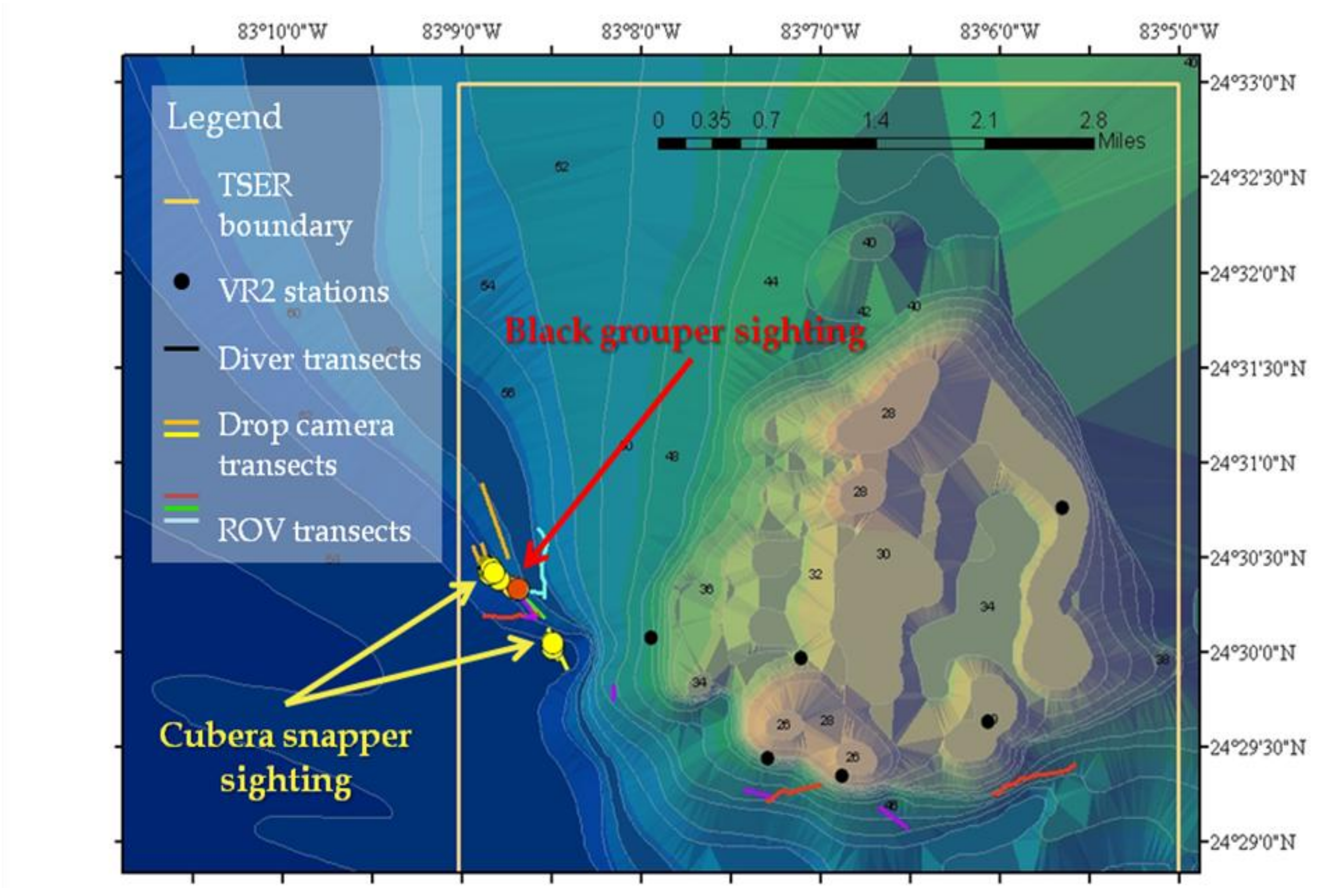

Figure 5. Riley's Hump with remote sensing transects and fish aggregation locations

Sampling Stations

58 VR2 stands were visited and serviced during the Nancy Foster research cruise. The VR2 receivers were brought back onto the boat, their data downloaded and their respective batteries changed and then re-deployed.

Remote Sensing Units

The ROV was deployed three times and the Drop camera five times, which recorded a combined 2 hours of video footage. Figure 5 shows the various locations the remote sensing units were deployed, as well as points to indicate the locations of aggregations of fish. Figures 6, below, are some still images from the ROV video of the schools of cubera snapper.

Figure 6. Still images of the schools of cubera snapper found at Riley's Hump

Summary and Future Perspectives

One objective of the research cruise was to check reports of snapper aggregations around the Riley's Hump area. Large schools of snapper were observed briefly by divers, but the aggregations were too deep for the shallow divers to record on video. The ROV was deployed at the same location, and was able to successfully record an aggregation of cubera snapper around 200 ft off the South-West edge of Riley's Hump. The cubera snapper were displaying spawning behavior, but no actual spawning was observed. The Nancy Foster split-beam (SIMRAD EK-60) sonar systems was then used along the south-west ridge of Riley's Hump and the coordinates of any large aggregations of fish were recorded. Based on the depth, divers or the ROV/drop camera were deployed to verify the species and size of the fish aggregations. Large aggregations of cubera snapper were once again observed as well as large schools of ocean triggerfish and horse-eye jacks.

Table 2. Remote sensing unit deployment coordinates and commercially important species recorded in the video

Date		Latitude	Longitude	Depth	Commercial Fish Species	Common Name	No. of Specimens
8/2/2012	start	24' 30.425	-83' 8.862	58-62 m	*Carcharhinus perezzi*	Reef Shark	1
ROV	end	24' 30.295	-83' 8.709		*Lutjanus cyanopterus*	Cubera Snapper	100-150
					Mycteroperca bonaci	Black Grouper	1
					Seriola dumerili	Greater Amberjack	2
8/2/2012	start	24' 30.397	-83' 8.797	55-58 m	*Caranx latus*	Horse-eye Jack	50-75
ROV	end	24' 30.216	-83' 8.593		*Carcharhinus perezzi*	Reef Shark	2
					Euthynnus alletteratus	Bonita	6
					Lutjanus cyanopterus	Cubera Snapper	20
					Mycteroperca bonaci	Black Grouper	4
					Seriola dumerili	Greater Amberjack	2
8/2/2012	start	24' 30.432	-83' 8.811	53-57 m	*Caranx latus*	Horse-eye Jack	1
ROV	end	24' 30.179	-83' 8.545		*Carcharhinus perezzi*	Reef Shark	1
					Euthynnus alletteratus	Bonita	25
					Lutjanus cyanopterus	Cubera Snapper	220-300
					Seriola dumerili	Greater Amberjack	4
					Sphyraena barracuda	Great Barracuda	1
8/3/2012	start	24' 30.418	-83' 8.894	60-63 m	*Carcharhinus perezzi*	Reef Shark	2
DropCam	end	24' 30.399	-83' 8.830		*Lutjanus cyanopterus*	Cubera Snapper	15-20
					Seriola dumerili	Greater Amberjack	1
8/3/2012	start	24' 30.474	-83' 8.861	58-62 m	*Carcharhinus perezzi*	Reef Shark	1
DropCam	end	24' 30.399	-83' 8.823		*Lutjanus cyanopterus*	Cubera Snapper	100-130
					Seriola dumerili	Greater Amberjack	1
					Seriola rivoliana	Almaco Jack	1
8/3/2012	start	24' 30.488	-83' 8.859	54-56 m	*Carcharhinus perezzi*	Reef Shark	2
DropCam	end	24' 30.380	-83' 8.813		*Lutjanus cyanopterus*	Cubera Snapper	110-140
					Seriola rivoliana	Almaco Jack	30
8/3/2012	start	24' 30.893	-83' 8.897	54-57 m	*Lutjanus analis*	Mutton Snapper	1
DropCam	end	24' 30.477	-83' 8.745		*Seriola rivoliana*	Almaco Jack	1

A follow-up research cruise was conducted on the P/V Peter Gladding from the Florida Keys National Marine Sanctuary in early September. The trip was primarily for downloading and replacing the VR2 receivers that were missed during the Nancy Foster trip, but a secondary objective was to re-visit the fish aggregation sites. Divers were able to successfully find an aggregation of cubera snapper, which was located a half-mile southeast of cubera snapper aggregations found during the Nancy Foster research cruise. The ROV could not successfully reach the aggregation due to high current, but video was recorded using the drop camera.

Combining the use of split-beam sonar and remote sensing units was an invaluable tool during the research cruises, which could pinpoint areas of interest and then immediately "ground-truth" the areas. This technique could be used to further map where different fish species aggregate around Riley's Hump, and determine if specific features or depths are preferred by certain species.

Future goals include monitoring and conduct acoustic tagging of cubera snappers in deeper waters of RH. The deployment of VR2 receivers west of the existing VR2 and in deeper water will allow us to get a more comprehensive knowledge of the aggregation and of the home range of this species. These activities require a large vessel with the capability of conduct fish trapping and the deployment of VR2. Additional ROV dives and mapping of the areas adjacent Riley's Hump and between RH and the DRTO are needed to extend estimations of species abundance.

Acknowledgement

We thank the crew of the Nancy Foster and the crew of the P/V Peter Gladding for their support during all the phases of this cruise. To Scot Donahue, Sean Morton and Sarah Fangman for making this happen. To the FKNMS crew and FWC crew for their high level of dedication and professionalism demonstrated during this cruise. Funding for this project is provided by NOAA /Coral Reef Conservation Program.